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ONE SHILLING AND SIXPENCE NET

but equally it is necessary for the experimenter in the counties to appreciate the reasons behind modern experimental layouts.

To explain some of these reasons, let us take the case of a simple manurial test with nitrogen (N) and phosphate (P), for which it has been decided to apply the following treatments : O, N, P, NP.

Why must the treatments be " replicated " and " randomized ", and not merely applied, in that order, in four strips across the field ?

Replication

The variability of soil conditions, the vagaries of pests and diseases, and chance differences of cultivations or manuring provide the first reason for repeating or " replicating " the treatments in separate groups or " blocks " ; even when care is taken to choose an apparently uniform experimental site, variations in yield equal to 20 per cent above or below the average yield (say between 8 and 12 tons for an experiment with a mean yield of 10 tons) commonly occur quite independently of the treatments applied. Unless the effect of a treatment is expected to be very large, it may be masked by these chance variations in yield, which, together with any actual mistakes in weighing or recording, form what is known as " experimental error " ; in the same way, a treatment which, in fact, does not effect the yield, may by chance appear to increase the crop. If, however, the treatments are repeated in several blocks, the chance of any one treatment being laid down on the poorest plot in each block is quite small, provided the order of the plots within the block is random and not systematic. Of course, much can be done to reduce the experimental error by taking greater care in choosing the site and at all subsequent stages of the experiment, by the use of compact blocks with plots as small as is convenient and practicable, or by the use of an experimental design, such as the Latin Square, specially suited to take account of soil variability.

While replication will enable the experimenter to make a more accurate assessment of the effect of the treatments applied, it will also give him an indication of the reliability of this assessment, and what reliance can be placed upon the results of the experiment if he compares the variation in the effect of the same treatment on the different blocks used. As an example, the responses to nitrogen in two experiments with potatoes were as follows :

Responses to Nitrogen (tons per acre)

	Experiment A	*Experiment B*
Block 1	2.2	4.1
„ 2	2.3	0.3
„ 3	1.8	2.9
„ 4	2.2	1.0
Mean Response	2.1	2.1

Both experiments give the same average or mean response to the treatment but for one of them (A), the result could be accepted with

confidence while for the other (B), the large differences between the replicates indicate that very little reliance can be placed upon the estimated average response.

Randomization

It is usual to express the reliability of an experiment by the " standard error ", calculated from the squares of the differences between plots similarly treated. It is important to note that a valid standard error cannot be obtained from an experiment unless the plots have been arranged in random order. While some arrangements in systematic order can be just as, if not more, accurate than those randomized, it is never possible to say just how correct. Also, most systematic arrangements are liable to give biased estimates ; for example, if the above treatments were arranged in two blocks as follows, without randomization :

O N P NP NP P N O

In this case, the nil treatment occupies outside plots and may therefore be more liable than are the other treatments to damage by birds, rabbits, etc. A properly randomized layout is therefore essential for any experiment. If the design is a complex one, the randomized layout will be provided by the statistician, but if it is simple the experimenter can perfectly well make up the order of plots himself. There is no mystery about the randomization process ; for many purposes it is simplest to use a table of random numbers such as the set mentioned by Fisher and Yates [1]. Random numbers can also be obtained quite simply by the use of a numbered pack of cards. Thus in the following example to randomize eight treatments (line 1), a number is allotted to each treatment (line 2) in any order. Eight playing cards numbered 1-8 are then shuffled well (line 3) to give the random arrangement shown in line 4.

1. Treatments	O	N	P	K	NP	NK	PK	NPK
2. Treatment No.... ...	1	2	3	4	5	6	7	8
3. Random No.	6	2	1	5	8	3	4	7
4. Random order of treatments	NK	N	O	NP	NPK	P	K	PK

The eight plots receiving these treatments will then form a " randomized block " ; an experiment made up of a number of these blocks is known as a " randomized block experiment."

The practical man need not fear that randomization of the treatments will materially increase the labour of laying down an experiment. In case of special difficulty, it is not necessary for all treatments to occur in every block ; for example, in an experiment including early-versus-late sowing, it is possible to sow, say, two blocks at one date and two at the other. The effect of sowing dates is then said to be " confounded " or identified with block differences.

When the number of treatments is small (3 to 6), it is possible to use the Latin Square, which usually gives more accurate results from

the same number of plots than could be attained by randomized blocks. It is necessary, however, that the individual plots should themselves be approximately square. The method of randomization is simple and is set out by Fisher and Yates [*ib*].

Factorial Design

It has already been mentioned that very often it is impossible to give a simple answer to the questions asked by the experimenter, and that it may be necessary to carry out an experiment which includes a number of different factors, such as seed rate, row spacing and date of sowing. Tests on a number of factors, both alone and in combination, are known as " factorial experiments ". Simple examples of such experiments are provided by what used to be known as the " 8-plot test " on fertilizers, which includes all combinations of the three factors, nitrogen, phosphate and potash shown on the previous page. One great advantage of factorial experiments is the possibility of adding factors to an existing trial. Thus, it was possible to add to an existing series of 32-plot trials on N, P, K and salt (S) for sugar-beet, an additional factor, boron (B). This was done without increasing labour beyond merely applying the boron. The following is a typical layout :

Block 1	2	3	4
NPB PSB	PKS KB	NPS NKS	NPKSB KS
PK KSB	PB S	P SB	B PS
O NKB	NKSB NPSB	K NB	NK PKB
NS NPKS	N NPK	PKSB NPKB	NSB NP

This type of layout may at first seem unduly complicated if one is used to only the simplest type of demonstration plot, but actually, the modern layouts, while demanding more care and thought in the field, often take little or no more time and energy than the older methods, and in terms of the amount of information obtained per unit of time and money expended, they are very much more efficient. There are two main reasons for this. One is that a factorial design carries what have been called " hidden " replications, so that it is usual for experiments involving all combinations of five factors each at two rates or levels (requiring $2^5=32$ separate treatments) to be carried out on only 32 plots, i.e., without any formal replication whatsoever. Since in the above trial there are 16 plots with, and 16 without, nitrogen (N), the effect of N will be determined with much the same accuracy as if the experimenter had laid down 16 pairs of plots, one plot of each pair receiving N, and one without N. In the factorial experiment, however, the same plot yields can be used over again to obtain information of equal accuracy on the effects of each of the other factors P, K, S, and B. Information is also obtained on what are termed the " interactions " of the different factors (i.e., the extent to which the response to one

factor is increased when it is applied in company with another factor). It would be possible to build up the same amount of information on the effects of the individual factors by carrying out a considerable number of simple trials, but these could give very little information on the interactions.

Another reason for the economy of the modern layouts is that they more or less automatically force the experimenter to reduce drastically the plot size. Nowadays it is becoming fairly general for cereals to be grown on plots of not much more than one-fiftieth of an acre, and root crops and grass for mowing on plots of one-hundredth of an acre, very accurate results being obtained. It is therefore surprising to find, in some parts of the country, experiments still being laid out on quarter-acre or even half-acre plots, each whole trial running to several acres.

Interpretation of Results

Once an experiment has been harvested, it is usual to send the results to Rothamsted for analysis, but if the experiment is not very complicated and the experimenter has access to a calculating machine, he will be well advised to analyse the results himself. A useful account of how to analyse simple experiments is given by Wishart [2]. Not only will the job be done quicker, but his knowledge of the experiment may enable him to pick out some treatment effect which would have passed unnoticed in the ordinary process of computation; but he must remember, however, to have the analysis properly checked, for it is fatally easy to make mistakes both in method and arithmetic.

The statistical analysis should provide not only a summary of the experiment, usually in the form of the average yields of treatments, but also a means of assessing the reliability of the results obtained—the "standard error" (S.E.). The standard error is widely used to test the reality of an observed treatment effect. Conventionally, such an effect is regarded as "significant"* if it exceeds about twice its standard error; thus the nitrogen response in Experiment A is:

Effect	*Standard Error*
2.1	±0.4 tons per acre

Thus, the above is clearly significant. A difference between two treatments is significant if it exceeds about three times the standard error of a single treatment. It should be borne in mind, however, that a significant effect is not necessarily a real one; even more important, failure to attain the significance level does not mean that a treatment is necessarily not effective. A treatment may therefore exert a real effect in each of a series of experiments and yet be adjudged "non-significant" in all of them; one would not dismiss it on this account, for one might merely have been carrying out the experiment with insufficient care, or with inadequate replication.

* i.e., a difference of such a magnitude would, on the average of a large number of trials, occur by chance only once in twenty trials.

The test of significance is very often made where it is not really relevant; in many field trials, the experimenter is concerned not so much with demonstrating the existence of a treatment effect as estimating its magnitude. This would be true, for example, of most fertilizer experiments. Thus we already know that potatoes need potash; for any given soil type we wish to know how much potash to apply, or more simply, what is the average response to a given amount of potash. The use of the standard error to test significance is of little interest here; instead we can use it to estimate the limits within which the treatment effect estimated by the experiment is likely to depart from the "true" effect, which would have been obtained had the soil and all other growing conditions been perfectly uniform over all plots. A divergence between the true and the observed values exceeding twice the standard error may, on the average of a large number of trials, be expected to occur by chance about once in 40 trials in a positive direction and once in 40 trials in a negative direction, i.e., once in 20 trials. A divergence in either direction exceeding the standard error would occur by chance about once in 3 trials.

Groups of Experiments

It cannot be too greatly emphasized that individual experiments, however much replicated and carefully carried out, are seldom of value by themselves. The number of replications required in a single experiment designed to detect treatment differences of, say, 10-15 per cent is of the order of ten, and the outlay of expense and effort involved would be better devoted to a series of smaller trials covering a range of sites and several seasons. The results of such a series should indicate the variation of the effects of treatments on the various soil types represented and the variation from season to season. Without this knowledge, advice cannot confidently be given to farmers. An experimental project should therefore be planned in advance to run for several seasons, preferably on specific soil types, even if this means that the total number of investigations being carried out has to be reduced. It is sounder policy to undertake a limited number of investigations from which clear-cut conclusions can be expected than to cover a wider field without achieving definite results in any direction.

Once a series of results covering different soils or seasons has been obtained, it is found that the variation from centre to centre and from year to year is of much greater importance than the experimental error of a single centre. The standard errors of the different experiments are then seen as a general indication of the weight which we should attach to the results of each centre. Normally, the statistical analysis will include a statement of the actual standard error (S.E.) per plot, followed by the S.E. per plot expressed as a percentage of the mean yield of the experiment, thus: Standard Error per plot=0.81 tons per acre or 12.4 per cent. It is worth remembering that, on average,

the standard error is about 8-10 per cent although, with careful work and good luck, values below 5 per cent can be achieved. For experiments with a percentage of over 15 standard error, too much reliance would not be placed on any observed effect unless it was large ; while if the standard error reaches 25 per cent or more of the mean yield, the experiment has suffered from such serious plot variability that in most cases it would be advisable to reject it as worthless.

References

1. Statistical Tables for Biological, Agricultural and Medical Research. R. A. FISHER and F. YATES. 1949. Oliver and Boyd, Edinburgh.
2. Field Trials : their Layout and Statistical Analysis. J. WISHART. 1940, Commonwealth Bureau of Plant Breeding and Genetics, Cambridge.

More detailed treatment of experimental design, etc., may be found in the following :

Memoranda on Colonial Fertilizer Experiments. A. B. STEWART and E. M. CROWTHER. (H.M. Stationery Office, 1947.)

The Design and Analysis of Factorial Experiments. Commonwealth Bureau of Soil Science, 1937. F. YATES.

N.A.A.S. QUARTERLY REVIEW INDEX

An Index of the articles and provincial notes contained in Nos 1 - 12 will be issued with the Summer number.

ABSTRACTS

ANIMAL BREEDING

New Zealand Department of Agriculture. Annual Report, 1950-51

Effect of Nutrition on Lambs and Wool Production

Experiments [1] have shown that, provided ewes are not underfed to such an extent that they lose weight during pregnancy, the level of feeding *prior* to lambing has very little effect on the birth weight of lambs, nor has it any significant effect on the growth rate of lambs which are satisfactorily fed from birth. But, both underfeeding and overfeeding prior to lambing have a tendency to increase the death-rate in lambs, while the level of feeding *after* lambing accounts for almost all the difference in the weight of lambs at weaning.

Wool growth in ewes is influenced much more markedly by the level of nutrition during pregnancy than during the suckling period, both in regard to quantity and quality of the wool produced.

The flushing of ewes doubled the number of twin births, and increased by 10-20 per cent the number of lambs per hundred ewes. It appears that a period of at least three weeks is necessary to obtain the maximum effect of flushing, and, contrary to expectation, the lambing season was spread over a longer period than was the case with the unflushed group.

Bull Fertility

Experiments with identical twin bulls, fed on vastly differing levels from birth until they were two years old, produced low-plane bulls which were only 61 per cent of the weight of their better-fed brothers. Their testicular volume and the power of sperm production of each group was in direct proportion to their weight.

After two years of age, all the bulls were fed on a high-level diet and, at two-and-a-half years, the bulls which were previously fed on the low-level diet had increased to 84 per cent, and at three years to 91 per cent, of the weight of the bulls which had the good start. There was no percentage increase in weight from three to three-and-a-half years and, at this age, both the testicular volume and the power of sperm production were in the same relative proportions as their weight.

It has been proved that full rations of silage do not reduce fertility in the bull. During 1950, two hundred and eleven bulls were examined to assess fertility, and fewer than 50 per cent could be considered satisfactory.

Identical Twin Experiments

The average difference in butterfat production, when widely-differing rations were fed over a period of three years to three groups made up of identical twins, showed that between twin sisters on the high and medium treatments, the difference was 80 lb.; between medium and low, 39 lb.; and between high and low, 131 lb. The experiment has permitted analysis of the variation between these groups. Of the total variation in butterfat yield, 50.6 per cent was due to heredity, 43.5 per cent to environment, and 5.9 per cent was contributed to error. This data is similar to a " between herd " study. If the environment factor is excluded, as in a " within the herd " study, it gives a variation, due to heredity, of 89.6 per cent.

These figures are much higher than are usually claimed for heritability of butterfat yield [2], and it is necessary to remember that they were obtained from the use of identical twins, and are much higher on that account. Nevertheless, on this basis, it is important to stress the need for the breeding of cattle possessing a high inherent capacity for production, irrespective of the environment, and of the level of nutrition they are to receive.

Eight pairs of twins, which had been fed together from birth until thirty days before calving, were divided into two groups. One group was " steamed up " and received concentrates at the average rate of 4 lb. of crushed barley and 1 lb. of linseed cake per day, whilst the other group received no concentrates. Both groups calved in good condition, and although there was a tendency for the " steamed " twins to show udder congestion, this was not sufficient to cause discomfort. Feeding levels and management after calving were the same, and although there was a difference in production in early lactation, it disappeared after fourteen weeks. With the exception of one set which was excluded because of mastitis, all the " steamed " group showed an increase in yield ; however, this was, on average, only 14.4 lb. of butter fat. On current New Zealand values, this level of increase is not sufficient to meet the cost of the concentrates used.

Dairy Cow Nutrition (Lifetime Project)

This is a continuation of the rotational-grazing and set-stocking[3] experiments, and its object is to examine the effect of the two types of pasture management on the lifetime performance of the dairy cow. The controlled group is rotationally grazed, grass is saved for autumn grazing, and a maximum of hay and silage is conserved so as to provide a high level of nutrition throughout the year. The set-stocking or uncontrolled group obtain a diet which naturally changes with the season.

At the end of the yearling stage, this controlled-grazing management gives on average an increase of 140 lb. in the live weight of each heifer.

Previous analysis showed that the well-reared heifers were more difficult to get in calf. Successful attempts have been made to correct

this difficulty during the past three years, and a marked improvement has been brought about by slowing up the rate of gain in the rotational-grazing group for the month previous to mating. Although the final number of conceptions for both groups are very similar, a slightly higher number of services is required for the better-fed group (1945-47, 1.95 : 1.45 services per conception ; 1948-50, 1.34 : 1.27).

The two groups—one on rotational-grazing, the other under set-stocking management—are sub-divided, at the first calving, into four groups. The average butterfat yield of the groups, which include over seventy lactations, made up of first, second and subsequent lactations, are as follows :

High-High 335 lb., Low-High 316 lb., High-Low 300 lb., and Low-Low 272 lb.

This cumulative data shows little difference from the production noted in previous years. There is a tendency for the poorly-reared cattle to approach the production of their well-reared mates when put on the controlled grazing. The well-reared cattle, up to first calving, also show a considerable increase over the set-stocking group, even when changed to the controlled farm.

References

1. I. E. COOP. *J. agric. Sci.*, 1950, **40**, 311-40.
2. I. JOHANSSON. *Animal Breeding Abstracts*, Commonwealth Agricultural Bureau, **18**, 1-12.
3. C. P. MCMEEKAN. *Report of Specialist Conference on Plant and Animal Nutrition in relation to Soil and Climatic Factors.* Australia, 1949.

W.L.

SOILS

Response of an Established Sheep Ley to Dressings of Sulphate of Ammonia. Pt. I. Yields and Botanical Composition of Herbage cut for Silage and for Hay. Pt. II. Effects on Chemical Composition of the Herbage. G. P. HUGHES and T. A. EVANS. *Emp. J. exp. Agric.*, 1951, **19**, 55-72.

PART I

The main object of this study was to compare the effects of differential dressings of sulphate of ammonia applied over a wide range of dates, both on the yield and on the botanical composition. The experiment extended over two harvesting years on a sward in poor condition, consisting largely of perennial ryegrass, with some timothy and red and white clovers. Sulphate of ammonia was applied at 0, 1, 2 and 4 cwt. per acre each month on different plots from February to November in 1946, and from March to May in 1947. Conservation as silage or hay was contrasted by cutting a half of each plot for either purpose. The largest increases in yield in 1946, both for hay and silage, were for the first cuts from the February, March and April applications (plots getting

4 cwt. per acre sulphate of ammonia gave approximately twice the yield of the nil plots). Sulphate of ammonia applied a month or less before cutting was less effective than earlier applications, but if applied two months or more before cutting, it brought about marked increases in yield. Residual effects were only important in the case of the heaviest dressing.

In 1947 it was possible to contrast autumn dressings applied in 1946 with spring dressings in 1947, and although the spring dressings gave slightly higher yields of silage, the differences were not significant. The response to nitrogen at all rates was also smaller in 1947, but this was due partly to the higher yields from the untreated plots compared with 1946.

The botanical composition of the cuts showed the usual effect of nitrogen at all rates is increasing the grass/clover ratio, but the proportion of unsown grasses was not affected until the second year, when they increased slightly. Both red and white clovers were depressed at all rates of nitrogen application, but especially so at the highest rates. The only difference between the autumn and spring applications was at the 4 cwt. per acre level, the depression of clovers being marked in both cases but slightly more for spring than autumn dressings.

Part II

Only the changes in the percentage crude protein were followed. Nitrogen may or may not increase the percentage crude protein. The earliest cuts for silage were on the whole higher in crude protein where nitrogen was applied ; the hay cuts did not show this advantage, except where nitrogen was applied less than a month before cutting. The percentage crude protein in subsequent cuts was related to the proportion of clovers in the sward, and as nitrogen normally depressed the clover content of the cuts, the untreated plots had the highest content of crude protein. Spring nitrogen did not give a greater production of crude protein per acre than autumn nitrogen, and only when applied a month before cutting did it give higher contents of crude protein.

W. M. D.
T. W. W.

Some Results of the Survey of Fertilizer Practice, 1950. B. M. Church, *Rothamsted Exp. Sta. Ann. Rep.*, 1950, 137-46.

The first Survey of Fertilizer Practice was carried out in 1942 in order to obtain evidence on average responses of different crops to varying amounts of fertilizers and the use made of available fertilizers.

A summary of the results of a further survey carried out in nine districts during 1950 is given in this paper. Ten or more farms from four groups of different acreages were chosen at random and details of fertilizer practice in random samples of fields in each farm were recorded. Where possible, soil analysis on the selected fields was also carried out.

A table giving the consumption of fertilizer in the United Kingdom shows that the annual consumption of nitrogen, phosphate and potash have about trebled since 1939.

Considerable variation in the use of farmyard manure and fertilizers on arable land from district to district is shown, nitrogen and potash

being used far more liberally in the arable farming district than in the grassland areas.

Figures are given which show that the rates of application of nitrogen and potash have increased greatly in the poorer grassland areas and in the dairy farming areas. The only large increase in fertilizers used in the highly farmed arable district has been in the potash fertilizers.

In studying the correlation between size of farm and quantities of fertilizers used it is found that generally the larger farm used more fertilizer per arable acre, and that use of fertilizer has been maintained on the larger farm while on the smaller farm it has increased.

In the highly arable districts, most of the farmyard manure is applied to the cash crops, potatoes and sugar beet, while in the grassland and dairying districts it is generally used on grassland.

There have been considerable increases of N, P and K used on both leys and permanent grass in the arable and dairying districts, while phosphate consumption alone has increased in the grassland district. The amounts of nitrogen and potash used were extremely small.

The percentage of the acreage of cereal crops which receive nitrogen varies from 78 in Wiltshire to 12 in Cardigan. Except in the arable areas, less than half the cereal acreage receives nitrogen and, where applied, the rates of application are low.

Potatoes in nearly all areas receive nitrogen at rates of about 0.8-1.0 cwt. N per acre. Sugar beet also received adequate dressings of nitrogen. The manuring of other root crops is reported to be far from satisfactory, less than 20 per cent of swedes and turnips in Cheshire and only 35 per cent of these in Northumberland received nitrogen.

Kale, which has been shown to respond to very heavy dressings of nitrogen, received it in only one half to two-thirds of the acreage and that often at only very light rates.

W. M. D.
E. R.

The Phosphate Reserves in Some Old Permanent Pasture Plots. R. B. Roy and B. Thomas. *Emp. J. exp. Agric.*, 1951, **19** (75), 175-84.

Phosphate fixation in soil has been much studied but, whilst Dyer investigated the after-history of phosphate applied to the Broadbalk Field at Rothamsted, no similar work has been carried out on permanent pasture of known manurial history.

The Tree Field plots at Cockle Park have received regular dressings of various phosphates, and the liveweight gains of sheep have been recorded, for over fifty years. The authors assumed that, at the beginning of the experiment, the soil was uniform and of the same phosphate level all over. It was possible to calculate the amount of phosphate removed and the amount added was known. The total phosphate was determined by two differing methods which agreed very well—in two-inch layers down to eight inches in depth, and in three-inch layers

from eight to twenty-three inches in depth. The maximum depth of penetration was the same in all plots, i.e., eleven inches, and lime and other fertilizers did not seem to have influenced this. The percentage recovery of phosphate varied from 85.7 to 98.8. It is possible that the calculation of the amount of phosphate removed by grazing stock was somewhat inaccurate.

The *available* phosphate was measured by two chemical methods the results of which agreed closely, and by pot experiments. Half the number of pots of soil from each plot were treated with superphosphate. Two crops of radishes were grown, and the dry-weight yields and the phosphate uptake determined.

From their experiments, Roy and Thomas draw the following conclusions, which would be important in the event of ploughing old grassland and would apply to the type of soil discussed. This is an acid-strong clay-loam, derived from boulder clay overlying a sandstone of the Millstone Grit series :

1. Of previously added but unused phosphate, over ninety per cent remains within ploughing depth where any of it that is available would be easily accessible to an arable crop.
2. A first crop could be grown without any phosphate fertilizer on land which, for many years, has received basic slag with or without other fertilizer.
3. Where little or no phosphate has been applied, a dressing would be necessary. This phosphate would give an immediate response, but the residues would be quickly fixed and annual dressings would be needed for some time.
4. Where superphosphate has been used at equivalent rates to slag, arable crops would not be grown without more added phosphate. This poor availability is probably due to acidity since, no lime having been used on these plots, the *p*H has remained low.

R.D.R.
W.M.D.

CROP HUSBANDRY

Potatoes

The increasing cost of growing potatoes, and the difficulty in obtaining labour for lifting them, make it essential to grow *good* crops. R. W. Ward (*J. Farmers' Club*, Part 6, 1951) deals with " Potato Problems," and offers the following " ten commandments " for potato-growers :

1. Select the variety according to the demands of your market, and plant as early as possible.
2. Use only dependable seed, preferably certified, or alternatively, once-grown from sound stock and lifted immaturely.
3. Keep a wide rotation, and remember that a clean potato's worst enemy is another potato rogue.
4. Practise deep ploughing, and, if indicated, subsoiling.
5. The potato being a very hungry feeder, treat it liberally but wisely with both humus and mineral manures, according to soil requirements.

6. At all stages of its cultivation, keep the plant in a free-working, well-aerated soil.
7. In the case of a main crop, prolong as far as possible the period of active growth.
8. Burn down or destroy haulm when the plant has reached its maximum growth of tubers, or when an infection of Blight has started.
9. If it is to be clamped, lift the crop only when the tuber skin is firm, and straw and earth up clamp immediately.
10. Having faithfully carried out all these nine commandments, don't spoil a year's work—and your reputation—by selling a badly dressed sample.

W. A. Scriven and C. M. Pool deal with the same subject, under the head of " Potato Growing," in the October and December, 1951, issues of *Farm Mechanization*. Part One is devoted to the cultivation of the ground, while Part Two is concerned with the choice of variety and seed, boxing and sprouting seed, riddles and sorters.

A recent book, " Early Potatoes " (Faber, 1951), by W. L. Thomas and P. W. Eyre, describes experiences in potato growing in Pembrokeshire. W. L. Thomas has published a summary of his recommendations (*Agriculture*, 1951, **58**, 429-34). Among the most interesting and possibly controversial points he makes are that the soil should on no account be over-cultivated in early spring ; that sets should be planted as near the surface as possible ; and that inter-cultivation should be kept down to the barest minimum, being completed before there is any risk of damage to the delicate rooting system of the plant.

Potato silage is the subject of an article by Tjalling Bakker (*World Crops*, October, 1951, 383-4) ; the product is mentioned also in *Power Farmer* (September, 1951, 109-11), where an article by D. N. McHardy describes the farms of Mr. John Mackie, at Laurencekirk, potato silage there forming part of the ration for over two thousand laying hens.

Research

Yet another periodical has been added to the long list of publications which seek to keep their readers abreast of developments in agricultural science. This is *Jealott's Hill Review of Agricultural Research*, which is " issued for the information of the Agricultural Research and Advisory Staff of Imperial Chemical Industries Limited and Associated Companies." The most recent issue (Summer, 1951, **1**, No. 2) contains material dealing with soils and fertilizers, crops and stock, plant-growth substances and weed control. Particularly useful, on the crops side, are the references to the effects upon weeds and upon the sprouting of carrots and onions, of old and new plant-growth substances.

Chemical weed control, and questions affecting a wide range of plant-protecting agents, are dealt with in *Search* (November, 1951, No. 3), issued by Plant Protection, Ltd.

G. E. F.
D. H. R.

MACHINERY

The Mechanization of Small Farms in European Countries. *Organization for European Economic Co-operation Report.*

This Report of the Machinery Sub-Committee of the O.E.E.C. deals with the suitability of mechanized methods for small European farms, and with methods that could be employed to extend the use of machinery where this seems desirable. A brief account is given of the present state of mechanization, and of such special aspects as the methods employed to assist the collective use of machinery.

The Report concludes that the main difficulties in the way of further mechanization of small farms are economic, and are due to the fact that in many countries both machinery and fuel prices are such as to make any high degree of mechanization unprofitable. The Report recommends overcoming these difficulties by such methods as reduction of fiscal taxes on tractor fuels, exemption of agricultural tractors from taxation, and reduction of import tariffs on agricultural machinery, as well as an extension of collective methods of machinery utilization and of agricultural credit.

Though the United Kingdom is included in the study, the Report is concerned more with the European countries in which mechanization is less advanced than in Britain.

Der Allradantrieb in der landwirtschaftlichen Praxis. Four-wheel drive in Agriculture. *Tech. f. Bauern u. Gärt.* G. PREUSCHEN. February 10, 1951, 67-8.

In Germany there is a considerable weight of opinion, both among research workers and some manufacturers, in favour of 4-wheel-drive tractors, though against this must be set the fact that several of the leading manufacturers remain unconvinced that the system is economic, owing to increased manufacturing costs. Dr. Preuschen, Director of a research institute at Bad Kreuznach, is one of the leading advocates of 4-wheel-drive. He reports on tests carried out with the Deuliwag 4-wheel-drive tractor, which has a Diesel engine of 22 B.H.P. and equal-sized drive wheels 6.5×32 in. with the engine mounted well forward. The tractor worked satisfactorily in a wide range of difficult conditions, doing jobs such as ploughing, beet harvesting and farmyard manure carting. Observed drawbar H.P. was up to 90 per cent of the B.H.P., and the statement is made that on difficult ploughing the tractor did as much work as a 40 H.P. steel-wheeled tractor of conventional design. The author considers this an ideal type of all-purpose, all-the-year-round tractor for small farms.

Farm Tractor Economics. Intelligent Operation and Its Effect on Costs. M. W. CROSS. *Power Farming in Australia and New Zealand*, 1951, **60**, 5, 17-23.

The article deals as much with safety and the dealer's responsibilities as with the subject indicated by the title. The author asserts that a person starting farming, or a small farmer, will do best if he mechanizes

from the start, rather than attempting to struggle along with horses and the help of an occasional contractor.

Discussing tractor wheel equipment, the statement is made that pneumatic tyres give a fuel economy 25 per cent better than steel wheels —a statement which seems to need at least some qualification. The author remarks on the need for setting out the wheels to maximum track width in order to improve lateral stability on steep hillsides.

Among the other points discussed are setting the carburettor to burn lean mixtures for light work and richer for heavier loads, and the addition of water ballast and retractable wheel strakes to improve wheel grip.

Development of Idaho Potato Harvesters. J. W. Martin and E. N. Humphrey. *Agric. Engng., St. Joseph, Mich.*, **32,** 261-9

Farmers in Idaho, as in so many other potato-growing regions of the world, are interested in machines which dig and sack or dig and deliver in bulk into vehicles.

With no suitable machines available from manufacturers, many Idaho farmers have developed their own harvesters, and in 1949 a survey in the State showed 1,450 harvesters, most of them home-built, which between them harvested 72,000 acres of potatoes. The Idaho Agricultural Experiment Station assisted farmers to develop their own machines by providing them with sketches, rubber for padding the digger in various places, and the use of special tools.

The type of diggers built varied considerably, but the soil-separating principle incorporated in almost all of them consisted of a rubber-covered elevator chain, followed by 3-inch diameter rubber rollers, similar to those used on one British make of potato sorter. It is claimed that the rollers are gentle in action, have a high separating capacity per square foot, and operate better in damp and muddy conditions than a vibrating chain belt.

As in Britain, difficult operating conditions in which stones and clods were a serious problem showed the advantage of an independent engine drive for the harvester mechanism. The article conveys the impression that while American manufacturers are tending to lag behind British in the development of complete harvesters, it may be worth while to keep an eye on some of the machines that American farmers are building for themselves.

Fundamentals of Artificially Drying Baled Hay. R. B. Davis and V. H. Baker. *Agric. Engng., St. Joseph, Mich*, **32,** 21-5.

The shortage of labour in Virginia has induced many farmers to use pick-up balers for collecting their hay. At the same time, many farmers in the state have experienced success in the barn drying of long or chopped hay. This has led a few farmers to try drying baled hay on barn-drying installations designed for long or chopped hay. Twenty-three of the 90 driers installed in Virginia in 1949 were for drying baled hay.

The paper deals with the problems of bale densities, static pressure-airflow relationships, uniformity of drying according to methods of

packing the bales, drying rates, etc. One of the difficulties to be overcome is that the drying air naturally tends to pass between the bales rather than through them. Conclusions include the recommendation that the bales should be stacked on edge, as close together as possible, and may be stacked to a depth of 6-8 bales. Moisture content at baling should not exceed 35-40 per cent. As a result of limited field observations it appears that a static pressure of about $\frac{3}{4}$ in. w.g. corresponds with an air flow of 15-20 ft./min.—figures roughly comparable with those for long or chopped hay. The necessity to use ventilating air of low relative humidity is reported, and drying temperatures used ranged up to 130°F.

Drying efficiencies approached those achieved with long and chopped hay, but the bales did not dry out uniformly, the top centre parts of bales remaining at a high moisture content for a long time after the bottoms and sides were reasonably dry. The effects on quality are not stated.

The method has some attractions, and seems to merit study and possibly experiment by research workers in Britain.

C. C.

FRUIT

Blossom Thinning by Sprays

The thinning of certain tree fruits is necessary to obtain fruit size, colour and quality and, especially with apples, to avoid biennial bearing. Thinning by hand takes much time at a busy season and is expensive. Considerable attention has, therefore, been paid in recent years to the possibility of thinning the crop by spraying during blossom or soon after. Research and practical experience on this subject have been summarized in "Fruit Thinning with Chemical Sprays," L. P. Batjer and M. B. Hoffman, *U.S. Dept. Agric. Circular*, 1951, No. 867.

Most attention has been given to the dinitro materials, though interest is growing in naphthalene acetic acid and its sodium salt. Apples are the crop most usually thinned in this way, though pears and stone fruits, especially peaches, have been experimented on to some extent.

Dinitro materials

Work on chemical sprays from 1932-35 showed that tar oil was the most effective of a number of chemicals in killing flower-buds when applied at the green-cluster stage ; here the aim was to prevent fruit set entirely. In 1939, promising results were obtained with dinitro-ortho-cyclo-hexylphenol, and it was found that Elgetol—a commercial preparation containing about 20 per cent sodium dinitro-ortho-cresylate—would prevent pollen germination when applied to the stigmas of flowers. Orchard trials of Elgetol during blossom showed great promise.

Results with Elgetol, dinitho-ortho-cresol (DN No. 2) and dinitro-ortho-cyclo-hexylphenol (DN No. 1) have been so variable that it is difficult to decide which is most effective. DN No. 2 has generally thinned more than Elgetol, but generally caused greater leaf injury, especially in cool, humid weather. DN No. 1 has given similar results

to Elgetol but caused even less leaf injury. In 1950 Elgetol was the most widely used material.

Most of the effect appears to be due to the prevention of germination of the pollen but there is some evidence that germinating pollen can be killed until the pollen tube is more than half way down the style of the pistil. Unopened flowers and those already fertilized are apparently unaffected. The best time for treatment appears to be at full blossom but treatments from one to three days later have been as effective or only slightly less so.

The effective concentration depends on weather, tree vigour, variety and possibly other factors, but is generally between a pint and a quart of Elgetol per 100 gallons.

Chemical thinning can be used with greater safety and dependability with varieties that tend to set heavy crops. Some of these varieties may require two sprays, the first a day or two before full-blossom and the seond one to three days later. In cool, humid blossom periods, dinitro sprays are likely to thin more heavily than in seasons with warm, dry conditions, possibly due to an indirect effect on fruits imperfectly fertilized or with a low seed content. Accurate timing is especially important when the weather is likely to encourage a heavy set, as this indirect effect does not then occur. Foliage injury to young leaves may occur but it is seldom important with Elgetol or DN No. 1.

The degree of spray cover must be varied according to the amount of blossom on each tree or part of tree, hence automatic sprayers are not suitable for this work.

Growth-Regulating Chemicals

Certain of the chemicals used for the control of pre-harvest fruit drop, i.e., naphthalene acetic acid and its sodium salt, have proved effective for thinning apples. This type of chemical is applied at any time from petal-fall up to three weeks later. The earlier timing brings the benefits of early thinning whereas the later one involves less risk of leaf damage and provides an opportunity for assessing the fruit set before deciding whether or not to spray. This is of particular value where spring frosts are a risk. The concentrations range from 5 p.p.m. to 20 p.p.m. and, as a rule, the later the spraying the higher the concentration that should be used.

In the U.S.A., the dinitro thinning sprays have been more satisfactory in the north-west, and the naphthalene acetic acid sprays in certain mid-west and east fruit areas. The dinitro sprays reduce fruit set immediately and thus exercise a greater control of biennial bearing than the naphthalene acetic acid sprays, which take effect some 3 to 6 weeks after blossom.

Chemical thinning sprays are not foolproof and cannot yet be generally recommended. Fruit-growers in the States are advised to try them on a small scale and they are warned that the results obtained may vary from year to year even in the same orchard. Considerable experience may be necessary to achieve the correct degree of thinning and the risk of over-thinning is very real.

H. B. S. M.

GLASSHOUSE CROPS

Soil Sterilization 1 : Ammonia and Nitrate Production in Some Glasshouse Soils following Steam Sterilization. J. N. DAVIES and O. OWEN, *J. Sci. Food Agric.*, June, 1951, **2.**

The production of ammonia and nitrate has been measured in several glasshouse soils after steaming, and the results can be very briefly summarized as follows :

Maximum ammonia production increases with the time of heating. Where soil is steamed *in situ*, i.e., in the border soil of the glasshouse, ammonia production is stimulated and increased concentrations are maintained ; no conversion to nitrate occurs for long periods. When the steamed soil is incubated and aerated periodically owing to sampling, ammonia concentration reaches a maximum comparatively quickly, then falls concurrently with rapid nitrate production. These differences are discussed in some detail. Contamination of steamed soil with unsteamed soil reduces the period of ammonification and accelerates the onset of nitrification. Aeration does not appear to be so essential where the contamination is deliberate. It is concluded that the high ammonia concentrations induced by steaming are not toxic to young plants. Evidence is given which suggests that ammonia production after steaming is accompanied by disappearance of nitrate. In so far as it may be measured by maximum ammonia production, a second steaming of the same soil is not so effective as the first.

Observations on the Chemical Changes Effected by the Steam Sterilization of Glasshouse Soils. T. W. WALKER and R. THOMPSON, *J. Hort. Sci.*, 1949, **25,** 19-35.

In the preparation of seed and potting composts, steam sterilization sometimes causes a severe check to growth, and in the border soils soft rank growth frequently follows steaming. This paper describes measurements of some of the chemical changes brought about by steaming. Although it has been generally accepted in the past that ammonia, the production of which is usually greatly increased by partial sterilization, is a likely toxic agent, the break-down products of the organic matter may also be partly responsible, as may the increase in water-soluble or exchangeable manganese.

Laboratory experiments show that the length of time for which steam is passed has little effect on the total production of ammonia. Five minute steaming is just as efficient as longer steaming in its effect on ammonification, and there appears to be a case for passing steam for as short a time as possible consistent with the destruction of harmful organisms. It is shown that after steaming, ammonification proceeds rapidly for about five weeks, then slows down and reaches a maximum after about two months. The ammonia concentration in glasshouse soils, before steaming, is in the neighbourhood of 10 to 15 p.p.m.

ammonia nitrogen (on the oven-dry soil basis), and the concentration one to two months after steaming reaches 50 to 150 p.p.m. At the same time, the nitrate concentration may be anything from 50 to 250 p.p.m. nitrate N. The total ammonia and nitrate N in steamed soils might, therefore, vary between 100 and 400 p.p.m., which is equivalent to about 1,000-4,000 lb. sulphate of ammonia per acre. " It is not difficult to attribute retardation in germination and in early plant growth to this high available nitrogen concentration, especially at the upper level."

Owing to the increase of water-soluble organic matter and manganese, which may also be toxic, it is difficult to decide from these experiments which of the three factors is responsible for the retardation in plant growth. One or all of them may be responsible.

Where lime was applied to an acid soil, ammonification proceeded rapidly after a week's delay, and the amount of ammonia finally produced increased with each addition of lime, within the limit of the experiments.

The production of ammonia and toxic organic compounds generally go hand-in-hand and will be greatest in rich soils of high *p*H, whereas toxic manganese will be greatest in steamed soils of low *p*H.

On rich soils with much readily decomposable organic matter, steaming at high moisture contents brought about production of more ammonia than steaming at lower moisture levels. This effect was not so marked on relatively poorer soils.

E. S.

FLOWERS

Crop Production. *Flor. Rev.*, 1951, **109,** 34-5.

This is a detailed report of a lecture by Dr. J. Seeley of Pennsylvania State College, on " New Developments in Florists' Crop Production," which covered a wide field and brought out several points of considerable interest.

An account is given of experiments on long-term cold storage of flowers, the principle being to reduce respiration and ageing to a minimum by keeping the flowers out of water and at a low temperature. Well-grown and disease-free flowers, freshly-cut, are sealed in air-tight waterproof containers, and kept at 31°F. The temperature must be controlled to within one degree, and good air circulation provided. After removal from storage, the flowers must be hardened by standing in water at 70°F., in a cool room (40-45°F.). Roses, gardenias and Wedgwood irises kept for two weeks ; carnations, narcissi and antirrhinums, four weeks ; chrysanthemums, six weeks ; tulips, eight weeks, and lilies for three weeks ; and on removal, all were in as good condition as freshly-cut flowers.

Discussing pot plants, Dr. Seeley described experiments on poinsettias showing that stock plants grow best and give the highest production of cuttings if grown between 70 and 80°F. When the pot plants reach the stage of bud initiation, formation of the buds can be delayed by a

night temperature of 75°F., but after buds have been formed, 60°F. night temperature gives the best colour and flower development.

Colour in hydrangeas is known to be associated with the amount of soluble aluminium in the soil. For good pink flowers, liberal quantities of superphosphate should be mixed with the potting compost used for forcing, to immobilize aluminium. To obtain a clear blue colouring, phosphorus should be omitted during forcing, and aluminium sulphate or nitrate applied in solution at the rate of one pound per gallon of water. Nitrogen status has more effect on colour even than soil *p*H, and for clear blue colouring, the nitrogen status should be low (see abstract below). Even at a *p*H as high as 6.7, a good blue was produced, provided the nitrogen level was low.

An interesting development in carnation-growing is the cold-storage of carnation cuttings. A small grower, who cannot obtain all his cuttings at one time, would find it of great assistance to be able to store cuttings for some months and root them all together. This can be successfully managed if fresh, turgid cuttings, taken early in the day, are prepared as for insertion and then put, slightly moist, into cellophane or polyethylene bags. A little moist sphagnum moss should be placed at the base of the cuttings, and the bag not sealed but merely folded over and held with a rubber band. The bags are then stored in the dark at a temperature between 30 and 40°F. On removal from storage, the cuttings should be allowed to warm up before insertion in the propagating bench. Rooting is rapid and even.

Among other subjects, Dr. Seeley described the production of flowers in winter from tuberous-rooted begonias (long-day plants) by giving four hours supplementary light in late summer and autumn, with a temperature between 50 and 60°F.

Greenhouse Hydrangeas. Neil W. Stuart. *Flor. Rev.*, 1951, **109,** 37-40.

It has been reported previously that low temperatures were necessary for, or at least conducive to, flower-bud initiation in hydrangeas. Cold storage in the dark before the middle of October, however, resulted in failure to flower. In these investigations at Beltsville , plants propagated from leaf-bud cuttings in April were grown in cold frames through the summer and batches were transferred at fortnightly intervals from August 10 to October 19 to a cool storage room at 50°F., for four weeks. While in store, the plants were given twelve hours' light daily from two-hundred-watt tungsten lamps in twelve-inch reflectors, hung two feet above the plants, giving a light intensity between sixty and one hundred foot-candles. At the end of four weeks, the plants were stored at 40°F. in the dark for six weeks, and then forced in the glasshouse at 60°F. All plants produced good quality blooms, and there was no blindness. Flowering dates were from January 29 to March 29, the shortest period for flowering from the beginning of treatment being with the plants where treatment had been started on October 19 (ninety days).

Extensive experiments were also carried out on the effect of varying periods and temperatures of cool storage on the flowering of plants during subsequent forcing at 60°F. Plants grown from leaf-bud cuttings in frames were transferred early in November to a cool glass-house and to cool storage rooms, at temperatures from 35 to 50°F., for varying lengths of time. At the time of beginning the treatments, the plants had differentiated flower-buds and were going dormant. The results, which are too lengthy and complicated to report in detail, showed that for the earliest bloom from naturally-matured plants, a minimum period of five or six weeks at temperatures of 35 to 40°F., was necessary. Storage for less time, or at higher temperatures, resulted in an excessively long forcing period, and extremely short plants. As an example, plants stored at 35°F. from November 2 until December 14, and then forced at 60°F., flowered on March 22, with a height of fourteen inches and a flower-truss diameter of seven-and-a-half inches. These may be contrasted with similar plants which were kept for the same length of time in a cool glasshouse and did not flower until April 12, with a height of ten-and-a-half inches and a diameter of seven inches.

Concurrently with these experiments, trials were made, on similar plants, of different fertilizer treatments applied after six weeks' storage at 35°F. The results are again lengthy and complex, but two points are worthy of note. Nitrogen had the greatest effect on plant and flower growth, and on colour, potash producing little effect, and phosphate influencing only colour. Plants receiving liberal applications of nitrogen (one ounce sodium nitrate in two gallons of water) had big, dark-green leaves and large, bright pink flowers. If sufficient nitrogen was applied, flowers tended to be lavender-coloured or of a muddy pink, even though the soil was nearly neutral. Moderate supplies of phosphate were necessary for a clear pink colour, and where a blue colour was required, it was essential to omit phosphate altogether (see abstract above).

R. H. S.

NUTRITION OF HORTICULTURAL CROPS

Manganese

The micro-nutrient, manganese (Mn) is responsible for causing possibly more trouble to the horticulturist than any other trace element. On neutral or alkaline soils it can be short, and on acid soils it can be present in excess. Under both conditions crop growth is affected and yields decline. The following two papers indicate some of the problems involved in the complex subject of the function of manganese in soil and plant.

Manganese Toxicity in Field and Market-Garden Crops. MARIE P. LOHNIS. *Plant and Soil*, 1951, **3**, 193-220.

The paper is well illustrated by both plate and coloured pictures. A series of experiments are described, dealing with different aspects of Mn toxicity.

SUGAR BEET STECKLINGS IN NORTHUMBERLAND
(See pp. 133–8)

A 2½-acre bed of stecklings at North Hazelrigg, near Wooler.
Sown July 5, 1951. Photograph taken August 30, 1951.

Holburn Grange : close-up showing number of plants per foot-length of drill.

SUGAR BEET STECKLINGS IN NORTHUMBERLAND

(See pp. 133–8)

Steckling crop at Holburn Grange (currant bushes on right).

In acid soil plots, *Phaseolus vulgaris* proved to be the best indicator plant for Mn excess. A characteristic leaf pattern was produced which could be simulated in solution cultures supplied with an excess of $MnSO_4$. Healthy leaves contain from 40-940 Mn p.p.m., whilst damaged leaves contained 1104-4261 p.p.m. At high temperatures, bean plants tolerated high contents in the foliage without visible injury.

Conclusive proof that the symptoms recorded were due to high content of Mn in the plant were confirmed by taking the acid soil, neutralizing with $CaCO_3$, and then adding $MnSO_4$. The elimination of acidity, by adding calcium carbonate, eliminated any other secondary effects due to the soil acid complex.

Other susceptible crops were *Vicia sativa* and *Medicago sativa*. A crop such as *Trifolium pratense* grew away from initial injury in the early stages of growth. *Trifolium repens* showed a lag in developing in the early stages of growth, but made a complete recovery. Flax, potatoes, tobacco, mustard, oats and strawberry appeared tolerant to high Mn in field tests. Tolerance to Mn excess appears to be due to a weak absorption, or to the ability of the plant in question to accumulate manganese which, in turn, does not interfere with growth processes.

Symptoms of Mn excess in *Phaseolus vulgaris* are not identical with iron deficiency, although it is recorded that water-culture experiments indicate that, at high temperatures, Mn excess induced Fe deficiency.

No correlation was found between exchangeable Mn in the soil and the content of Mn in the plant.

The Manganese and Iron Contents of Crop Plants as determined by Chemical Methods. D. J. D. Nicholas. *J. Hort. Sci.*, 1949, **25**, 60-77.

Three experimental centres are described where the availability of soil Mn to crops was low, medium, and high, respectively. Symptoms of deficiency occurred at the first centre, but were absent from the second, while symptoms of excess were apparent at the third. Mn was estimated in the crops by rapid methods (tissue tests), and also *in toto* by ash analysis. Good agreement was obtained between these two methods used for material from all three centres. At the centre where Mn deficiency occurred there was no seasonal trend of the content, which was low, in the leaves. The Fe/Mn ratios in the plants varied from 4 to 32. At the centre where crop growth was normal, distinct seasonal trends were recorded in Mn level for crops such as sugar beet, potato and cauliflower. At this centre, the Mn content of crops was affected by different manurial treatments. For instance, high levels were found in N.P. treatments and low levels in those receiving stable manure.

A potato experiment was used on the centre (acid soil) where the Mn content in the soil was high. The syndrome of Mn excess was complicated by deficiencies of Ca, K, Mg, P and N. The Fe/Mn ratio varied from 0.12 to 0.35. There was no evidence at this centre that Mn excess caused Fe deficiency.

It is concluded from these experiments that the Fe/Mn ratio has no practical significance.

W. P.

PLANT BREEDING

Minerva Maple Pea

Minerva Maple (described in a leaflet issued in November 1951 by the National Institute of Agricultural Botany) is a new variety of field pea bred from a cross between a Finnish and a Tasmanian Maple pea, by Dr. G. D. H. Bell at the Plant Breeding Institute, Cambridge. It ripens about fourteen days earlier than Marathon Maple, and is about eighteen inches shorter in the haulm ; under some conditions, it outyields Marathon Maple, and is usually less severely damaged by pea moth. Seed of this new variety has now been offered for sale by the National Institute of Agricultural Botany.

Black Fly and Beans

In the third of a series of papers on varietal resistance of *Vicia Faba* to *Doralis fabae*, H. J. Müller [1] reports the behaviour of winged migrants in relation to a susceptible (Schlanstedt) and a resistant (Rastatt) variety of field bean. In mixed plantings of the two varieties, four or five times more migrants settled per day on Schlanstedt than on Rastatt, this difference also being observed when whole blocks of Rastatt were compared with whole blocks of Schlanstedt. Even varying the distance between plants of the two varieties, sown together, did not markedly affect the preference for Schlanstedt. There seems little room for doubt that Müller has established a consistent difference in the behaviour of black fly on these two varieties, and that this difference does not depend on the aphids being offered a choice between the two varieties.

Müller believes that the aphids are attracted to bean plants by smell, and that Rastatt is less attractive than Schlanstedt. Experiments, which he conducted to establish this point, led to rather inconclusive results, and it would seem that part of the difference observed must be ascribed to the behaviour of aphids after they have actually alighted on the plants.

The problem of varietal resistance to black fly in beans has hitherto been particularly intractable. Müller's contribution to the analysis of this problem seems to be a valuable one ; behaviour studies on aphids at Cambridge, part of which have been summarized by Kennedy [2], also throw light on the problem of host choice. It seems possible that plant breeders will soon be able to select beans for their unattractiveness to aphids, and thus make a contribution to reducing the danger of catastrophic infestations by black fly.

Resistance to Stem Eelworm in Red Clover

The importance of *Ditylenchus dipsaci* as a pest of red clover is well-known. S. Bingefors [3] has studied the behaviour of the clover strain of this species on a resistant (Merkur) and a susceptible (Ultuna) variety of red clover. He inoculates seedlings by inverting them in a suspension of nematodes ; then by fixing in hot acetone, and staining with osmic acid (Flemming's solution), he determines the percentage of plants infested and the number of nematodes per infested plant, at different intervals after inoculation. The initial infestation is from 75 to 80 per cent in Ultuna, and from 60 to 65 per cent in Merkur. Over a period of 10 weeks, it dropped to about 6 per cent in Merkur, while in Ultuna it did not decrease at all. Practically all the plants in which nematodes were found after a 10-week interval, also had nematode eggs present. The number of nematodes per infested plant was higher in Ultuna than in Merkur. Bingefors concludes that the resistance shown by Merkur in the field is mainly due to the hindrance it offers to the development and to the reproduction of the nematodes, resistance to penetration being of relatively minor importance. He points out that similar conclusions have been reached concerning other parasitic nematodes. The onion, oat and rye strains of *D. dipsaci* also penetrate Ultuna somewhat more readily than Merkur, but fail to reproduce in either variety.

A number of red clover strains were grown on heavily-infested land, and their survival was estimated in tenths of a full stand. In laboratory inoculation experiments, the percentage of seedlings with nematode eggs was determined. The two measures of resistance were strongly correlated ($r = 0.888$). It seems, therefore, that the laboratory test gives a fair indication of resistance in the field.

Autotetraploidy in Lucerne

Using a white-flowered, cream-seeded variant, E. H. Stanford [4] has shown that segregation in respect of this character in lucerne is tetrasomic. This is the third leguminous forage crop in which tetrasomic inheritance has been demonstrated, the other two being bird's foot trefoil and sainfoin. It seems possible that the chances of a species coming into cultivation as a herbage crop are somewhat improved if it is an autopolyploid. The reduced fertility of autopolyploids is less of a handicap in herbage crops than in grain crops.

The Mendelian genetics of tetrasomic organisms is of a different order of complexity from that of disomics, and it is still too early to say what effect this discovery will have on breeding systems used with lucerne. The simpler systems have already been found to work quite effectively, but other systems may yet be devised which take advantage of the special features of tetrasomic inheritance.

Barley Breeding

G. D. H. Bell [5] has reviewed the current work on barley at the Cambridge Plant Breeding Institute. In two-row spring barleys for malting, promising selections have been obtained from the crosses Kenia

× Spratt-Archer (H.B. 34), Kenia × Plumage-Archer (H.B. 35) and Maja × Spratt-Archer (H.B. 40). The objectives have been varieties of both early and medium-early maturity, combining Kenia's short straw and high yield with the high malting quality of Spratt-Archer and Plumage-Archer. Lines have been selected, which are an improvement on Kenia in respect of both yield and quality. In view of the success of these crosses between the best English malting varieties and successful continental varieties, a further series of crosses has been made, using the more promising of the newer continental varieties with our native varieties.

Other work described includes the improvement of two-row winter barley for malting, breeding for mildew resistance in both spring and winter barley, and the development of feeding barleys.

References

1. Über die Ursachen der unterschiedlichen Resistenz von *Vicia faba* L. gegenüber der Bohnenblattlaus *Doralis fabae* Scop. III. Über das Wirtswahlvermögen der schwarzen Bohnenblattlaus *Doralis fabae* Scop. H. J. Müller. *Züchter*, 1951, **21**, 161-79.
2. Aphids and Plant Growth. J. S. Kennedy. *New Biology*, 1951, No. 11, 50-66.
3. The Nature of Resistance to Stem Nematode, *Ditylenchus dipsaci* (Kühn) Filipjev, in Red Clover, *Trifolium pratense* L. S. Bingefors. *Acta Agric. Scandinavica*, 1951, **1**, 180-9.
4. Tetrasomic Inheritance in Alfalfa. E. H. Stanford. *Agron. J.*, 1951, **43**, 222-5.
5. Barley Breeding and Related Researches. G. D. H. Bell. *J. Inst. Brewing*, 1951, **58** (**48** N.S.), 247-60.

J. L. F.

DAIRY BACTERIOLOGY

Special attention is drawn to the review—Section B. Bacteriology and Mycology applied to Dairying, by E. R. Hiscox and A. Hirsch. *J. Dairy Res.*, **18**, (2), 195.

Keeping Quality and Raw Milk Grading III. Comparison of Keeping-Quality Tests and Dye Tests in Milk Control. Results of a Field Trial.

This paper by A. Rowlands and Zena Hosking (*J. Dairy Res.*, 1951, **18**, (2), 166) completes the reports of all the work which was done in a series of experiments conducted under the same general title. The previous papers were abstracted in Nos. 10 and 12 of the N.A.A.S. Quarterly Review.

Milk samples from two hundred and ninety-eight farms in eight widely-separated areas of England and Wales were examined at fortnightly intervals throughout a period of one year.

The examinations were made by the routine resazurin test, the methylene blue reduction test (4½-5½ hours), the methylene blue reduction test (½ hour), and a temperature-compensated keeping-quality

test using clot-on-boiling (C.O.B.) as the end point. For both evening and morning milk, two standards were used—a residual keeping quality at 22°C. of 21 hours and 24 hours, reckoned from nine o'clock on the morning of the day when the milk is collected from the farms.

The proportion of farms and of samples which passed each test was much greater in winter than in summer, and reflected the prevailing atmospheric temperature. Nevertheless, some farms consistently complied with the standards. Only 5 per cent of the total failures were ascribed to the sixty good farms, but 37-60 per cent of the failures to comply with the various standards were found on the sixty worst farms.

Tests which are designed to indicate the care taken in the production and handling of milk on the farm, must determine the quality of the milk at the time it leaves the farm. If a test cannot be started at this stage, samples must receive identical treatment in the pre-test period of storage, or adjustment must be made to compensate for the effects which variations in treatment during the pre-test storage period have on the test results.

For this purpose, the C.O.B. test, as used in these trials, is suitable because it gives a measure of the residual keeping-quality of milk when it leaves the farm, after variations in shade atmospheric temperature have been compensated.

In any bacteriological test of milk samples, temperature affects the initial numbers and the subsequent proliferation of bacteria in milk during storage at the farm. The quality of the milk delivered by the producer is profoundly dependent on these factors. But the producer cannot control variations in the pre-test storage temperature of samples and, if it is desired to measure the actual keeping-quality of the milk which he delivers, the effect of temperature variations must be eliminated. Unless the methods of production and handling are consistently good, producers will be unable to comply with the standards set by any test—especially in summer, when temperature conditions demand extra vigilance.

A standard for the C.O.B. test of 21 hours at 22°C. in summer and 24 hours at 22°C. in winter, would correspond approximately to that now imposed by the methylene blue test ($4\frac{1}{2}$-$5\frac{1}{2}$ hours).

Bacteriological Tests for Milk Sampled during Distribution to the Consumer

At present, the keeping quality of raw and pasteurized milk, as delivered to the consumer, is determined by different official tests. From the consumer's point of view, there seems to be little justification for this procedure. So long as the milk is safe, he is interested mainly in the fact that milk will keep sweet from delivery to delivery. At the request of the Ministry of Food, an extensive experiment, in which many laboratories collaborated, was undertaken to find a single test

which might be applied to raw and to pasteurized milk. The results are reported by A. Rowlands and Zena Hosking (*J. Dairy Res.*, 1951, **18,** (3), 268. The methylene blue (4½-5½ hours) test, the methylene blue (½ hour) test (shade storage), the methylene blue (½ hour) test (20°C. storage), the clot-on-boiling test (C.O.B. shade storage) and the clot-on-boiling test (C.O.B. 20°C. storage) were used. Over a period of one year, milk samples were taken from producer-retailers distributing their own designated *raw* milk, and from dairies distributing designated *raw* milk from farms, their own *heat-treated* milk, or *heat-treated* milk processed at other dairies.

As in previous work, failures with all tests were less numerous in winter than in summer. The proportion of failures with the atmospheric shade temperature at 70°F., or even at 75°F., was not appreciably greater than at temperatures up to 65°F.

In June to September, 62 per cent of samples were taken when maximum shade temperature exceeded 65°F. In summer, the C.O.B. tests (shade storage) gave the lowest incidence of failures, followed by the C.O.B. test (20°C. storage), the methylene blue (½ hour) test (shade storage) and, for designated raw milk, the 4½-5½ hours methylene blue test. In winter, the methylene blue (½ hour) test (shade storage) gave about the same number of failures as the C.O.B. test (20°C. storage). Failures with the methylene blue (½ hour—20°C. storage) were much more numerous, and, for designated raw milk, were about the same as with the methylene blue (4½-5½ hours) test. Dairies selling their own processed milk had the lowest proportion of failures with all tests. In summer, especially, dairies selling heat-treated milk from other dairies had a much higher proportion of failures. Some dairies had no failures by any of the tests.

The arguments for and against the various tests are set out, and the choice seems to be between the methylene blue (½ hour) test after shade storage, and the C.O.B. test after storage at 20°C.

The Deterioration of Milk Rubbers. 1. The Effect of Micro-Organisms. N. J. Berridge. *J. Dairy Res.*, 1951, **18,** (3).

The author has established that, although the sulphur bacteria and organisms able to decompose rubber may easily be isolated, they do not appear to contribute to spoilage of rubbers in this country.

Biochemical and Serological Properties of Some Citric Acid Fermenting Streptococci from Milk and Dairy Products

P. F. Swartling (*J. Dairy Res.*, 1951, **18,** (3), 256) has investigated the bacteriology and serology of a large number of strains of lactic streptococci which produce acetoin. They were shown serologically to belong to Group N and otherwise to resemble *Str. lactis*, except that they utilize citrate, producing CO_2, volatile acids and diacetyl. It is considered that the name *Str. diacetilactis* (Matuszewski) might be given to organisms of the type described.

This paper is of special interest to those interested in starters of many types.

Bacteriological Aspects of the Reworking and Blending of Stored Butter

E. R. Hiscox and A. G. House (*J. Dairy Res.*, 1951, **18,** (3), 291) have shown that, when stored butter is re-worked, the organisms comprising the flora resume growth and, as they are often taint-producing types, they may hasten deterioration. When sweet cream and ripened (acid) cream butters are blended, they may contain more types of organisms than when each is re-worked separately, and the conditions may become even more favourable for bacterial growth.

The Inhibition of an Anaerobic Spore-Former in Swiss-Type Cheese by a Nisin-Producing Streptococcus

A. Hirsch, E. Grinsted, H. R. Chapman and A. T. R. Mattick (*J. Dairy Res.*, 1951, **18,** (2), 205) have shown that normal cheese may be made when nisin-producing streptococci are incorporated in the starter, even using milk heavily infected with anaerobic spore-formers (which cause great loss of cheese because of "blowing"), since the activities of the causative organisms are inhibited.

Thermoduric Organisms in Milk : I and II

In Part I of this work by S. B. Thomas, J. W. Egdell, L. F. L. Clegg and W. A. Cuthbert (*Proc. Soc. appl. Bact.*, 1950, **13,** (1), 27), a valuable review of the literature is given. In Part II (*ibid*, 1950, **13,** (2), 124), preliminary observations on methods of testing are recorded.

Pollution of Water Supplies from Shallow Wells, and Measures for its Prevention

From the data obtained by the bacteriological examination of water from shallow wells in Northern Ireland, N. R. Knowles (*Proc. Soc. appl. Bact.*, 1950, **13,** (2), 292) concludes that, provided the infiltration of surface water is prevented and care in construction and renovation taken, wells of this type may supply water of satisfactory quality.

A.T.R.M.

MYCOLOGY

Studies on Systematic Fungicides. I. Fungicidal Properties of the Aryloxyalkylcarboxylic Acids. S. H. Crowdy and R. L. Wain. *Ann. appl. Biol.*, 1951, **38**, 318-33.

In their introduction, Crowdy and Wain give a brief review of the few previous publications on this subject. Their own experiments examined the fungicidal activity of chemical compounds which were likely to be readily translocated within plants. The compounds mainly used were Aryloxyaliphatic acids which were chosen as being unlikely to possess growth-regulating activity. Most of the tests were carried out with Chocolate Spot of broad beans caused by *Botrytis cinerea* and *B. fabae*. Leaves of broad beans were readily infected with both organisms by being kept in a saturated atmosphere at 17°C. after spraying with a spore suspension in 1 per cent dextrose solution. *B. fabae* was a more suitable fungus, as it produced more distinct lesions. Various methods of assessing the amount of disease present were used, the most useful being one in which the mean size of the lesions was estimated.

The compounds tested were applied to the plants by spraying, by injection and through the roots, the latter method proving the most satisfactory. In this method, 10 p.p.m. of the acid tested was added to distilled or purified water in which the bean seedlings were raised. Compounds which proved promising in these preliminary tests were then used with potting plants, being added to the soil in sufficient quantity to give a concentration of about 100 p.p.m. by weight of soil. The following compounds were ineffective :

2-Chlorophenoxyacetic acid
2 : 6-Dichlorophenoxyacetic acid
2 : 6-Dichloro-4-methylphenoxyacetic acid
2 : 6-Diiodo-4-methylphenoxyacetic acid
*2 : 4 : 6-Tribromophenoxyacetic acid
*2 : 4 : 6-Triiodophenoxyacetic acid
1 : 4-Dichloro-2-naphthoxyacetic acid
*3-Chloro-4-iodo-5-bromobenzoic acid
*a-Phenoxphenylacetic acid
a-(2 : 4-Dichlorophenoxy) phenylacetic acid
B-(2 : 4-Dichlorophenoxy) propionic acid
B-(1-Naphthoxy) propionic acid
B-(2-Naphthoxy) propionic acid
B-(1-Chloro-2-naphthoxy) propionic acid
B-(1-Chloro-2-naphthoxy) propionic acid

*Caused damage to the plants

Though showing some promise in one trial a-(2-Naphthoxy) phenylacetic and 2 : 4 : 5-Trichlorophenoxyisobutyric acids give erratic results. Phenyl 3 : 5-Dimethyl-4-Nitrosopyrazole in two tests reduced the amount of disease as compared with the control by 37-42 per cent. The most successful compounds used were :

2 : 4 : 6-Trichlorophenoxyacetic acid
2 : 3 : 4 : 5 : 6-Pentachlorophenoxyacetic acid
2 : 3 : 4 : 5 : 6-Pentachlorophenoxisobutyric acid

which on an average of at least seven trials with seedlings in water reduced the amount of disease by 37, 33 and 27 per cent respectively. In a trial on seedlings in pots watered with 50 p.p.m. of the test substances for 3 weeks before inoculation, 2 : 4 : 6-Trichlorophenoxyacetic acid, 2 : 3 : 4 : 5 : 6 : Pentachlorophenoxyacetic acid and 2 : 3 : 4 : 5 : 6-Pentachlorophenoxyisobutyric acid all caused a statistically significant reduction in the amount of disease compared with untreated controls. They were not so successful in a second trial in which the plants were watered with a 100 p.p.m. of the acids for 2 weeks, but in this trial the amount of disease present was very low, even in the controls. In other experiments, plants were inoculated at intervals of 1, 3 and 5 days after watering with 2 : 4 : 6-Tricholorophenoxyacetic acid. In all cases there was a substantial control of the disease at about the same level, indicating that the substance was rapidly absorbed but did not appear to accumulate in the plant tissues. In a further experiment, concentrations as low as 2 p.p.m. of each of the Phenoxy acids caused a significant reduction in the amount of disease. To test the persistence of these compounds in the soil, sufficient of each was added to give a concentration of 100 p.p.m. by weight of the soil. Successive crops of bean seedlings were then grown, inoculated with Botrytis and assessed for disease. 2 : 4 : 6-Trichlorophenoxyacetic acid and 2 : 3 : 4 : 5 : 6-Pentachlorophenoxyacetic acid each caused a reduction in disease in up to four successive sowings in some of the tests, indicating that they persisted in the soil for a considerable period, although no precautions were taken to stop leaching. One trial was made with fully grown bean plants in a garden in the open. They were watered with 2 : 4 : 6-Trichlorophenoxyacetic acid and 2 : 3 : 4 : 5 : 6-Pentachlorophenoxyacetic acid each at a concentration of 500 p.p.m. and the plants were inoculated a week later. After a further 4 weeks the amount of disease present was assessed and both substances caused a reduction in pod infection, while 2 : 4 : 6-Trichlorophenoxyacetic acid also reduced the amount of disease on the leaves.

Experiments in which the acids were sprayed on to the leaves gave erratic results. However, in some experiments one stem of a double-stemmed plant was sprayed and the whole of the plants later assessed for amount of disease in comparison with control plants, which were sprayed on one stem with a wetting agent alone. The size of the lesions on the plants receiving the acid spray was smaller even on the unsprayed part of the plant, indicating the systemic effect of the acids. In a very limited field trial, the acids were sprayed on to plants at a concentration of 500 p.p.m. plus 0.5 per cent wetting agent. Four compounds were used but only one produced a significant reduction in the amount of disease. Positive results were also obtained in experiments in which the acids were injected into the bean stems through a wick. There appeared to be a tendency for the phenoxy acids to accumulate in the actively growing tissues and not in the older parts of the plants, which was a disadvantage with this disease, as Chocolate Spot tends to be more severe on old leaves. The compounds did not appear to persist for any

length of time and to obtain good control of the disease it would be necessary to give a number of doses of the chemical.

Some of the compounds used which were not successful as fungicides produced damage to the plants. Of the successful ones, 2 : 4 : 6-Trichlorophenoxyacetic acid caused slight root damage in some experiments on seedlings in water. This compound and also both the pentachloro acids caused a reduction in dry weight of the seedlings, though this was less evident when the plants were grown in soil. The appearance of plants treated with these substances did not differ from that of untreated controls.

H.E.C.

ENTOMOLOGY

Insects and Human Affairs. V. B. Wigglesworth. *Essex Fmrs' J.*, 1951, **30,** 25-31.

This is a reprint of a broadcast and gives an interesting and wide view of man's fight against insect pests in the past, the present state of affairs and a discussion of possible trends in the future. It is pointed out that man's aim should not be to destroy insects completely, but to limit their multiplication. The most important limiting factors are biological—competitors, predators, parasites and infectious diseases—and the prevalence of these factors may be influenced in turn by the weather. Under natural conditions, this competition damps down the more violent fluctuations in population.

When large areas of land are occupied by a single kind of plant, the fauna becomes much more simple and this creates a tendency to marked fluctuations. For this reason insect pests are particularly troublesome in the U.S.A. Fields in our own country are small, crop rotation is practised and the hedgerows maintain a large complex of insect predators and parasites. The biologist would like to be able to restore and maintain this natural balance of insect populations as part of normal agricultural practice. Today, however, the move is constantly towards more intensive cultivation, increased mechanization and larger fields. The question is whether it is still possible to aim at natural control in the face of increasingly artificial conditions.

Recent advances in the chemical control of insects have undoubtedly been very great, but there exists a danger. The use of very persistent insecticides such as DDT has, in practice, sometimes seriously affected the balance of populations of insects, because it has proved even more potent as a killer of the parasites and predators than it has of the insect pests. For this reason there is a school of thought which feels that no insecticide should be released for general use until it has been studied for some years so that its long-term effects are known.

Similar dangers may be lying in wait for us with the rapidly increasing use of chemical weed-killers. This also raises entomological problems ; many insects which are important as pollinators depend much on wild flowers, besides those of cultivated plants. Bumble bees are becoming

increasingly scarce in the U.S.A., and the production of clover seed is being affected. Were the roadsides and hedgerows also to be " cleaned up " with weed-killers, quite serious results might follow.

The biologist has a deep sense of the complexity of living communities and feels that, with increasing knowledge, it should be possible to devise methods of cultivation which would favour the crop and discourage the insect pests to the point where a satisfactory balance was established. While there is certainly no question of abandoning the use of insecticides, there is great scope in finding out just what the various insecticides are doing. It is possible that some of our insecticides are too potent. Milder insecticides which will reduce a pest and have little or no effect on its natural enemies may, in the long run, prove to be the more valuable. The future of chemical insecticides, it is suggested, lies in their use as " a complement to the more subtle and more remunerative methods of biology."

The Gladiolus Thrips—A Pest New to Britain. P. Aitkenhead. *Agriculture*, 1951, **52**, 517-23.

This paper gives information concerning records of the gladiolus thrips (*Taeniothrips simplex*) in various countries and describes how it was first discovered on gladioli in Britain in July, 1950, in a Middlesex nursery. The pest was then found to be common in that area, and subsequent examinations by Provincial Advisory Entomologists showed it to be present in many other districts.

The thrips are planted with the corm and they are carried up with the growing shoot, feeding upon the leaves. Later they crawl beneath the bracts of the young flower-spike, where they feed and reproduce on the stems, bracts and buds, going through the larval and pupal stages. Warm, dry summers are the most favourable ; large numbers are killed by heavy rain, and usually by the autumn the population has been much reduced by weather conditions, so that only a small number reach the corms and return to the store. The survival of gladiolus thrips out of doors over the winter in this country is unlikely.

On the whole, spraying with benzene hexachloride emulsion has given the best control in the summer, but spraying must begin early (when the plants are about 6 inches high) and it must be repeated at intervals.

Control in the winter may take the form of fumigation with naphthalene ($\frac{1}{2}$-1 oz. grade 16 per 100 corms in shallow trays, placed in a draught-free store). The store should be kept at a temperature of 70-75°F. for 18-21 days. This treatment should not be used on sprouting corms.

Fumigation with methyl bromide or calcium cyanide has also proved satisfactory but is more difficult to carry out.

As an alternative, corms may be dipped in a solution of mercuric chloride (corrosive sublimate), consisting of 1 oz. of the chemical to 6 gal. water. Hot water treatment has also given successful control.

Dusting the corms with 5 per cent DDT is recommended in the U.S.A. It is used at the rate of 1 oz. per bushel in trays, or 1 teaspoonful per 100 corms in paper bags, as soon as possible after harvesting.

L.N.S.

PROVINCIAL NOTES

EXPERIMENTS ON THE MANURING OF POTATOES IN THE WEST MIDLAND PROVINCE

T. W. WALKER

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One important advantage resulting from the setting up of the N.A.A.S. has been the increased possibilities of carrying out field experiments. This is true at any rate in the West Midland Province, and after early difficulties had been overcome it was possible to embark on a large number of experiments covering a wide range of interest. The importance of the potato crop naturally led us to give early attention to experiments on the manuring of potatoes. Whilst experiments on potatoes have been fairly numerous throughout the country, local information was scanty and inadequate to answer all advisory queries. General advice had to be based on the summarized results of experiments in the West Midlands quoted by E. M. Crowther and F. Yates[1].

For better or worse, one of the noticeable features arising from the war-time rationing of fertilizers was the manufacture of compound fertilizers of fixed plant food ratios designed to meet the needs of individual crops (e.g., National Compound No. 1 (7% N, 7% P_2O_5, 10½% K_2O) for the potato crop). The main advantage arising from using such fertilizers is that no gross unbalance in nutrition is likely to arise, but their exclusive use makes no allowance for soil variations.

However, in view of the wide use of N.C.F. No. 1, it was considered desirable to find out over a number of years the optimum amount to apply. Simple experiments (Type 1) were devised to compare dressings of this compound at 0, 5, 10, 15 and 20 cwt. per acre, and the results are discussed below. Such experiments, of course, give no information on the effects of the separate plant nutrients (N, P and K), and accordingly another series of experiments (Type 2) was initiated to compare all combinations of N, P and K at three rates, with the usual $3 \times 3 \times 3$ NPK layout. These experiments give information not only on the possible effects of the three nutrients, but will in time, along with experiments on other crops, allow us to correlate the responses to P and K with the results of soil analysis. This latter is now such an important feature of advisory work that it becomes very important to know if the time and expense involved are justified. For instance, on a potash-deficient soil a farmer must be convinced that it will be worth while to mix his own fertilizer to supply more potash than usual, or run over the field with extra potash, rather than just to put on an increased dressing of complete compound.

Experiments involving the use of dung are not numerous, because of the difficulties of application. Nevertheless, in the West Midlands many potato crops are dunged, and if we are to be in a position to give

advice on the use of fertilizers it is necessary to carry out experiments involving the use of dung. So far only a few such experiments have been carried out, but the results warrant a continuation and expansion of this type of experiment. This series of experiments (Type 3) consists of 4 blocks, two with and two without dung, with all the 8 combinations of NPK in each block. It is a simple type of experiment and, owing to the dung being applied in blocks, is not susceptible of any great accuracy.

It will be best to discuss the results of the various types of experiments separately, and then to assess their value in guiding the District Officer in his advisory work.

Type 1 Experiments—Levels of Manuring of Potatoes

These experiments compare dressings of 0, 5, 10, 15 and 20 cwt. N.C.F. No. 1 (7% N, 7% P_2O_5, 10.5% K_2O) on the total yield of potatoes. The fertilizer was applied by hand after the land had been ridged up, and prior to planting the potatoes ; the ridges were then split back. It is important to make this point in view of the findings of G. W. Cooke[2], that this is a more efficient way of using fertilizer than broadcasting on the flat.

During the three years 1948-50, 24 experiments were carried out, and it is possible only to present the general means for each year. In some experiments dung was applied all over and these experiments are separated from the rest.

Only four experiments were carried out in the presence of dung, and it is not safe to draw any conclusions, except that the increases in yield are not marked after application of more than 5-10 cwt. of fertilizer. Climatic conditions during the three years were very variable, 1948 and 1950 being wetter and 1949 drier than usual. These conditions are reflected in the lower mean yield for 1949 compared with the other years.

Total Yield of Tubers—General Means of all Experiments

(*tons per acre*)

Cwt. of Fertilizer per Acre	1948		1949	1950		All Years
	8 expts. without dung	3 expts. with dung	8 expts. without dung	4 expts. without dung	1 expt. with dung	20 expts. without dung
0	7.2	12.2	8.1	8.2	8.7	7.8
5	10.2	13.6	9.8	11.0	12.5	10.3
10	11.7	13.4	10.4	12.4	14.7	11.5
15	13.0	13.6	10.5	13.2	15.0	12.2
20	13.9	14.2	11.1	14.1	14.8	13.0
Mean	11.2	13.4	10.0	11.8	13.1	

In the last column of the above table the average yields for 20 experiments without dung are shown. They demonstrate the well-known Law of Diminishing Returns, and from the smooth curve

obtained by plotting yields against amount of ferilizer used, the following table is obtained :

National Compound No. 1 *cwt.*	*Response in tons per acre* *Average for 20 experiments*, 1948-50
5	2.4
10	3.7
15	4.5
20	5.0

By reconstructing the curve, an estimate of the probable response to each extra cwt. of fertilizer from 0-20 cwt. per acre can be obtained, and from the various costs and prices in operation in any given year, it is possible to calculate the most profitable dressings of fertilizer to apply. In the two wet years the most profitable dressing works out at rather more than 15 cwt. of fertilizer per acre, but in 1949 it is only 10-11 cwt. As the extra outlay for quantities of fertilizer exceeding 15 cwt. per acre in 1948 and 1950 only returned a relatively small profit, it is perhaps reasonable to assume that it will seldom be profitable to apply more than 15 cwt. of fertilizer per acre, and indeed this would be wasteful in a dry year. As a general rule, therefore, in the absence of dung, and at existing prices, we feel fairly safe in the West Midlands in recommending dressings of N.C.F. No. 1 at the rate of 15 cwt. per acre ; if there are any marked fluctuations in prices, it is still possible to calculate the most profitable dressings of fertilizer to apply, by making use of the form of response curve, $y=y_0+d\ (1-10^{-kx})$, where y is the yield with a fertilizer dressing of x cwt. per acre, y_0 the yield with no fertilizer, d the limiting response and k an assumed constant.

If C is the cost of fertilizer (N.C.F. No. 1) per ton and V the value of a ton of potatoes, then the optimal dressings of fertilizer for various C/V ratios are as follows :

Compound Fertilizer *cwt.*	*C/V Ratio*
5	7.1
6	6.4
7	5.7
8	5.2
9	4.7
10	4.2
11	3.8
12	3.4
13	3.1
14	2.8
15	2.5
16	2.2
17	2.0
18	1.8
19	1.6
20	1.5

As an example, it is interesting to calculate the C/V ratios for fertilizers before and after the price increases of the last year or so, assuming that the farmer gets the same price for his potatoes (say, £7 per ton after making allowances for harvesting the heavier crop).

The C/V ratio prior to the increase in price of fertilizers would be £11 10s.÷£7=1.6, and the optimal dressing would therefore be about 19 cwt. of fertilizer per acre, with the last few cwt., however, giving very little extra return. At the new fertilizer prices, the C/V ratio would be approximately £20÷£7=2.9, and the optimal dressing of fertilizer would be near 13 cwt. per acre. Of course, if the farmer received £10 per ton (the approximate present-day value) for his potatoes, the C/V ratio would then be 2 and the optimal dressing of fertilizer would be 17 cwt. per acre.

No great accuracy can be claimed for these figures because of seasonal variations in response, but advice on manuring can be based on fairly safe ground if, for a given C/V ratio, a quantity of fertilizer is applied approximating to the optimal dressing or preferably rather less because of the small return for the last few cwt. Where dung is applied, clearly less compound should be used, but these experiments do not allow an accurate estimate to be made. It should be fairly safe to recommend using 5 cwt. per acre less of fertilizer where dung is used, but as will be seen later, it would be better to use the same amount of nitrogen but reduce the amount of phosphate applied and perhaps the potash too.

Type 2 Experiments—3×3×3 NPK Experiments on Potatoes

In these experiments, three levels of N, P and K were tested in all combinations, at the following rates in the absence of dung. One experiment in 1950 was dunged all over.

N_0 =No sulphate of ammonia
N_1 =2½ cwt. sulphate of ammonia per acre
N_2 =5 „ „ „ „
P_0 =No superphosphate
P_1 =2½ cwt. super per acre
P_2 =5 „ „ „ „
K_0 =No potash
K_1 =1½ cwt. sulphate of potash per acre
K_2 =3 „ „ „ „ „ „

So far, ten experiments of this type have been carried out in 1949 and 1950. It is possible only to present the mean yields for the various treatments ignoring the interactions.

There were large variations in responses to the different fertilizers at the various centres, the response to 5 cwt. s/a varying from nil to over 3 tons per acre, for 5 cwt. super from nil to 2 tons per acre and for 3 cwt. sulphate of potash from 0.4 to 7 tons per acre. Clearly the most important fertilizer for potatoes in the West Midlands is potash, followed by nitrogen and, finally, phosphate.

It is difficult to estimate accurately the most profitable amounts of fertilizer to use because of the interactions, but at prices ruling in 1949-50, on the average of all experiments they would be approximately 4-5 cwt. sulphate of ammonia, 2½-3 cwt. superphosphate and 3-4 cwt. sulphate of potash per acre. As 15 cwt. N.C.F. No. 1 supply approximately 5 cwt. s/a, 6 cwt. superphosphate and 3 cwt. potash, it would appear that the phosphate content could be safely reduced and the potash content

increased, if this were possible from the manufacturing point of view. With the present fixed plant food ratio, uneconomic amounts of phosphate are being applied in order to supply enough potash and nitrogen.

Mean Yields of Potatoes

(*tons per acre*)

Treatment	1949					Mean Yields for 1949	1950					Mean Yields for 1950
	Stottesdon	Hampton-in-Arden	Hixon	Ismere	Oakmere		Westbury	Torton	Hampton-in-Arden	Chetwynd	Hixon	
N_0	5.5	5.1	11.5	4.5	5.6	6.4	14.9	14.3	5.6	9.9	9.3	10.8
N_1	8.1	5.0	11.8	5.6	6.5	7.4	15.0	14.0	9.0	12.6	11.7	12.5
N_2	9.0	5.6	11.9	6.3	7.0	8.0	15.3	13.3	9.3	13.0	12.4	12.7
P_0	7.1	5.0	11.6	4.8	6.2	6.9	13.8	14.0	8.4	11.8	10.4	11.7
P_1	8.7	5.5	11.5	5.6	6.8	7.6	15.5	14.2	7.6	11.5	11.5	12.1
P_2	6.9	5.3	12.2	6.0	6.1	7.3	15.9	13.5	8.0	12.1	11.6	12.2
K_0	6.6	4.8	10.8	3.3	5.3	6.2	14.6	13.6	5.5	9.7	7.1	10.1
K_1	7.4	5.6	12.0	6.1	6.6	7.5	14.7	14.1	8.5	12.5	12.1	12.4
K_2	8.7	5.3	12.5	7.1	7.1	8.1	15.9	14.0	10.0	13.2	14.2	13.5
Mean	7.6	5.3	11.7	5.5	6.3	7.3	15.0	13.9	8.0	11.8	11.2	12.0
S.E. ±	.57	.34	.26	.26	.43		.33	.32	.49	.26	.62	

The effect of the wet season in 1950 is clearly reflected in the average yield of 12.0 tons for all treatments, compared with the average yield of 7.3 tons in 1949.

It is too soon to attempt to correlate responses to phosphate and potash with soil analytical data, but the results indicate quite clearly a very close correlation between " available " potassium and the response to potash fertilizers. This, of course, is to be expected in view of the high potash requirements of potatoes. The correlation between " available " phosphate and response to phosphate is not so close, but in these experiments potatoes have not responded to phosphate as much as is sometimes stated, and large numbers of experiments will be needed before it is possible to assess the value of soil analysis in picking out the soils responsive to phosphate for the potato crop. There is no difficulty with high and very low levels of phosphate, but the intermediate categories are presenting the problem. In the case of potash, soil analysis gives clear guidance as to the need for extra potash or otherwise. One of the reasons for the relatively low responses to phosphate may be that in the West Midlands, intensive root-cropping is usually restricted to the light and medium-textured soils, which are, on the whole, less deficient in phosphate than the heavier-textured soils. This would also account, to some extent, for the relatively larger responses to potash.

The Torton and Hixon centres for 1950 afford an interesting comparison. The soil analysis was as follows :

Centre	*p*H	Available P_2O_5 (N/2 acetic)		Available K_2O (Morgan's extract)	
		mg. %	Classification	mg. %	Classification
Torton	6.2	23	High	14	Satisfactory
Hixon	6.7	6	Low	4	Very Low

The Torton soil would be considered a first-class arable soil by any method of assessment and a long history of high farming is reflected in its high content of phosphate and potash ; there was no response at all to manuring in this experiment, not even to nitrogen, because shoddy applied to the previous crop in the dry season of 1949 had not decomposed. The site at Hixon was a poor stony soil, which had carried three straw crops since the war-time airfield was ploughed out in 1946. Analysis rates it deficient in phosphate and very deficient in potash and yet by proper manuring (which could have been arrived at by prior analysis) it yielded just as heavy a crop of Majestics as at Torton. If the two sites had been manured on the basis of soil analysis, however, the Torton crop would have cost much less to grow.

Type 3 Experiments—Dung NPK Experiments on Potatoes

These experiments consist of four blocks, two with and two without dung, with eight plots in each block with the following treatments :

O, N, P, K, NP, NK, PK, NPK, where
N = 4 cwt. per acre sulphate of ammonia
P = 4 „ „ „ superphosphate
K = 1½ „ „ „ sulphate of potash

So far only three experiments of this nature (all in Cheshire) have been carried out, one in 1949, and two in 1950. The results are as follows:

Mean Yields
(*tons per acre*)

Centre	Dung		Nitrogen		Phosphate		Potash		* Standard Error of Means
	Absent	Present	Absent	Present	Absent	Present	Absent	Present	
Reaseheath 1949	9.86	17.09	12.85	14.11	13.48	13.48	11.64	15.32	±0.290
High Legh 1950	10.88	14.50	11.94	13.45	12.13	13.25	11.92	13.46	±0.230
Barthomley 1950	7.06	11.22	8.68	9.59	9.06	9.21	8.37	9.91	±0.371

* Not applicable to comparisons between Dung and No Dung Plots.

Dung has had outstanding effects at all centres, but particularly at Reaseheath in 1949, a dry year. At the other two centres the plots receiving dung alone gave yields of $3\frac{1}{2}$ tons per acre in excess of the control plots compared with 7 tons at Reaseheath. Sulphate of ammonia gave increases in yield ranging from 0.9 to 1.5 tons per acre. Phosphate was relatively ineffective save at High Legh, and responses to potash ranged from 1.5 to 3.6 tons per acre.

As dung has given the greatest increase in yield (and a much bigger percentage of ware potatoes), it is worth examining the interactions in the presence and absence of dung :

	Nantwich	Bathomley	High Legh
	tons	*tons*	*tons*
In the absence of dung, N increased the yield by	0.86	0.94	1.48
„ „ presence „ „ N „ „ „ „	1.66	0.88	1.55
„ „ absence „ „ P „ „ „ „	−0.11	0.36	0.72
„ „ presence „ „ P „ „ „ „	0.12	−0.05	1.51
„ „ absence „ „ K „ „ „ „	5.01	0.85	2.40
„ „ presence „ „ K „ „ „ „	2.26	2.24	0.68

In agreement with Crowther and Yates' observations, dung did not reduce the response to nitrogen. The effect of phosphate was small except at High Legh, where it gave a bigger apparent response in the presence of dung than in its absence. Potash still gave marked though reduced responses in the presence of dung, except at Barthomley where, in the presence of dung, potash apparently increased the yield. The most obvious reason for this divergent result is possibly because of variations in the composition of the dung, but the dung was unfortunately not analysed.

The following conclusions may be drawn tentatively from this series of experiments :

1. Dung can be relied upon to give profitable increases in yield.
2. There is no need to reduce the amount of nitrogen when dung is used and it should be profitable to apply as much as 4-5 cwt. per acre sulphate of ammonia.
3. Phosphate has only given a response at one centre where dung was used, but none of these soils was deficient in phosphate.
4. Potash at $1\frac{1}{2}$ cwt. per acre has still given profitable increases even where dung was used and even more potash might profitably be applied ; however, in all cases these soils were deficient in potash.

These results largely substantiate the conclusions to be drawn from the Type 2 experiments as to the relative importance of the main plant nutrients.

By continuing to carry out experiments of this nature, it is clear that in time, the accumulated evidence will materially assist in advisory work, particularly when taking into account the results of soil analyses. The general requirements of the potato crop in the West Midlands should become well-established, and dressings of fertilizers can then perhaps be profitably modified on the basis of soil analysis. In this respect, it is

perhaps unfortunate that National Compound No. 1 is such a popular fertilizer for potatoes. Whilst it possesses undoubted advantages in times of emergency, its exclusive use makes no allowance for variable soil phosphate and potash contents, and there is perhaps a good case for the production of compound fertilizers, especially made to take into account the results of soil analyses. At least there are good grounds for regional differences in composition. At present the farmer who mixes his own fertilizers is usually in the best position to profit from the results of field experiments and soil analyses.

References

1. Fertilizer Policy in War-time. E. M. Crowther and F. Yates. *Emp. J. exp. Agric.*, 1941, **9**, 77-97.
2. Placement of Fertilizer for Potatoes. G. W. Cooke. *J. Agric. Sci.*, 1949, **39**, 96-103.

SUGAR BEET STECKLINGS IN NORTHUMBERLAND

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The production of sugar beet stecklings is a comparatively new enterprise in Northumberland farming. A very small acreage of stecklings has been grown for several years on one or two farms, but it was not until 1950 that this crop assumed a place in the county's agricultural output.

The severe attacks of Virus Yellows, experienced by growers of sugar beet and sugar beet seed in the eastern counties during the last six years, has induced research on possible methods of controlling the disease. There was little doubt that stecklings infected with Virus Yellows in autumn played an important part in carrying the disease over to the following spring, and, apart from reducing the potential yield in the seed crops, the stecklings also acted as a source of early infection for the main crop. It was thought that Northumberland would be one of the most suitable areas for growing virus-free stecklings and a trial, conducted by Dr. R. Hull, in co-operation with member firms of the Sugar Beet Seed Producers' Association strengthened this belief in 1948-49*. In this trial, stecklings raised in Scotland and the North of England showed only 0.25 per cent infection with Virus Yellows and yielded 22.8 cwt. of seed per acre, compared with 94.34 per cent infection and a yield of 14.7 cwt. per acre from stecklings raised in Eastern England. In 1950, all contracts made between the British Sugar Corporation and Seed Producers stipulated that at least 50 per cent of the tonnage of sugar beet seed must have been produced from stecklings which were grown in virus-free areas.

The climate of Northumberland is fairly well-suited for the production of stecklings. Summer rainfall is usually well-distributed and, in consequence, there is little risk of poor germination, even when the

* Virus Yellows: Need for Healthy Stecklings. R. Hull. *British Sug. Beet Rev.*, 1950, **3**, 107-11.

seed is sown during June or July. The amount of sunshine is generally sufficient during July, August and September to promote good, steady growth, and severe frosts are not normally experienced before the end of October.

Cockle Park rainfall figures for the months June to November, in 1949 (a dry summer), 1950 and 1951 are given below :

	1949	1950	1951
	inches	*inches*	*inches*
June	0.97	1.92	1.81
July	1.78	3.89	1.84
August	2.31	3.88	4.83
September	0.93	3.71	0.83
October	3.32	1.22	0.74
November	2.36	5.41	6.88
	11.67	20.03	16.93

The 1950 Crop

About seventy acres of sugar beet stecklings were grown on contract with seed firms. The main areas of production were centred around Alnwick, Morpeth, Wooler and Hexham, on arable-feeding and arable-dairy farms. The shortage of labour on farms situated away from the main urban towns and the higher rainfall experienced to the west of the county, limited the possible area of production to the above centres. A survey of thirteen farms in the county showed that the acreage grown on individual farms varied from one to twelve and that the average was four. The stecklings were grown on soils ranging in type from light, sandy soil in the Wooler district, to medium-heavy clay soils around Morpeth. Stecklings were grown on a portion of a " root " field or on part of a corn field which would benefit from spring fallowing.

Cultivations and Manuring

On most root fields the land was deep-ploughed during the winter months and cross-ploughed once or twice in the spring. Further ploughing was not generally practised, but the land was worked with a cultivator or disc harrow at fortnightly or three-weekly intervals prior to the final preparation of the seed bed. By taking two or three weed crops in May and June it was hoped that the stecklings would be able to grow away from any weed competition. The actual amount of cultivation required to produce a satisfactory seed bed varied considerably from farm to farm, but this is not surprising in view of the wide variation in soil type. All final cultivations were designed to produce a fine and firm seed bed, while retaining the maximum amount of moisture possible. On the light soils, and where stecklings were grown adjacent to a corn crop, the fields were generally spring-ploughed and then worked as for heavy soils, with the same object in view.

The seed firms require a plant of which the crown should measure not less than three-eighths of an inch, and preferably not more than

one inch in diameter. In order to secure plants of this size, the application of farmyard manure and "artificials" was reduced considerably, compared with the normal dressings which are given to root crops. Many of the growers applied only 2 cwt. of superphosphate per acre, others gave a dressing of 2-4 cwt. potassic super per acre, while, on the light land in the Wooler district, some growers applied 2-4 cwt. of compound fertilizer per acre. Light applications of farmyard manure were generally ploughed in where the crop was grown on a "root" field. Lime was applied where soil analysis indicated a shortage.

Sowing and After-Cultivations

Contrary to the general practice of root growing in Northumberland, all seed was sown on the "flat" and, with the exception of one field, was sown during either the last week in June or the first week in July. Plants grown on a field which was sown during the third week in July did not develop to the required size before lifting time. The seed was sown with various types of drill, including a tool-bar attachment, and corn and combine drills adapted for the purpose. The distance between the drills varied from 6 – 22 inches, but the majority of growers spaced the drills at 7 or 12 inches apart, in the hope of securing a high plant population per acre. Seed was provided by the contracting firms and sown at the rate of 26 – 33 lb. per acre. Since growers were not required to single the crop, the use of processed or segmented seed did not appear to offer any distinct advantage and all seed was sown in the cluster form.

By the end of July it was obvious that the pre-cleaning of the land had failed to prevent serious weed competition. Beds sown in drills twelve inches or more apart were cleaned with wheeled push hoes or tractor-mounted tool-bar equipment, or both, but where the drills were only 6 or 7 inches apart, mechanical cleaning was impossible, and the crops undoubtedly suffered from weed competition.

Lifting and Clamping

The difficulty of lifting stecklings under adverse weather conditions, and with little or no experience of this operation, presented a considerable problem to the growers. Rainfall during September and October (see Cockle Park figures) resulted in a prolonged corn harvesting period, at the end of which potatoes, roots and stecklings were all waiting to be lifted. On most farms, potato harvesting took priority over stecklings, and by the time the former had been lifted, the ground was in a very wet condition. Heavy rains during November made the situation worse, and on two farms in the Morpeth district, where the soil was particularly heavy, efforts to harvest the crop had to be abandoned after only a part had been lifted. Numerous methods of lifting the plants were tried and various attempts were made to mechanize the process. The seed firms want stecklings with well-shaped roots, free from fanginess and reasonably clean. They also require that the

long, thin taper of the tap root be removed, in order to facilitate easy transplanting, and that leaves be cut off three to four inches from the crown, thus reducing both the risk of heating in clamps and the cost of transporting the stecklings south.

Some growers pulled the stecklings by hand and removed the " tops and tails " with a turnip hook, or cut the tops with a mowing machine before lifting, severing the roots with a garden spade, after laying the plants in rows. An ordinary grass cutter, with the swathboard removed, was found to be an efficient implement for removing the excess of leaf. For lifting the plants, several types of potato-digger and elevator-digger machines were tried out but, on the whole, results were unsatisfactory. Other machines, specially designed or improvised for the job, also proved to be of little use. A simple tool, in the form of one or two " L " hoes mounted on a tractor tool-bar, proved to be the most useful on many farms. After cutting the tops with a mowing machine, the hoe blades were used to cut the tap roots at a regulated depth (about four inches) and, at the same time, to loosen the soil around the plants without burying them or covering the crowns. Labour gangs working on the potato-stretch system then pulled the plants, removed the bulk of the soil adhering to the roots, and threw the stecklings into heaps or baskets. It was noticeable that the type of land appeared to be more important than the type of implement used and that some implements which worked on light land would not function in clay.

Stecklings sown in drills six to thirteen inches apart yielded from 220,000 to 365,000 usable plants per acre. Only 136,000 usable plants per acre were harvested from one crop sown in drills twenty-two inches apart.

After lifting, the stecklings were carted to the roadside ready for transporting south and, where they were not required immediately, were put into clamps simply constructed by placing straw bales in two parallel rows nine feet apart. The stecklings were heaped between the bales to a depth of fifteen to twenty inches and covered with loose or bottled straw. This type of clamp proved to be most efficient where plants had to be stored for two to four weeks. Some stecklings remained in the ground all winter and were lifted in March. These plants did not appear to have been seriously damaged by the winter frosts but the ground was still very wet when they were lifted, and a large amount of soil must have been transported south with the stecklings, thus considerably increasing the haulage costs. Seed firms paid for the transport of stecklings from Northumberland to the Eastern Counties.

Costs of Production

Detailed costings of the enterprise are not available but an attempt was made to estimate the cost of production from data supplied by a number of growers in the Morpeth, Alnwick and Wooler districts. The average estimated cost of production per acre (from first ploughing

to the completion of lifting) amounted to £60, of which lifting accounted for £48 or eighty per cent of the total cost. The lowest estimated cost was £35 per acre, and the highest £70. Since the publication of these figures in the county, some growers have stated that they produced the crop for under £35 per acre, and several farmers hope to harvest the crop for £30 per acre in 1951. There is no doubt that the high average cost of production, as estimated above, was due chiefly to the abnormal weather conditions at lifting time, the heavy nature of the soil on several of the farms where data was collected, and the lack of experience in handling the crop.

Diseases

Virus Yellows was identified on some of the steckling beds but, of the crops affected, less than one per cent of the plants were found to be infected with the disease. A sample of plants from all the steckling beds in the county was transplanted in plots at the Rothamsted Field Station, Dunholme, Lincoln, and observations on Virus Yellows infection and plant establishment were recorded in 1951.

The 1951 Crop

Sixty-eight acres of sugar beet stecklings were sown in twenty-one beds on seventeen farms in the county. Ten of the beds were situated in the Wooler district, three around Hexham, six near Alnwick and two in the extreme south-east of the county near Tynemouth; all were on light or medium, easy-working soils. On sixteen farms, the seed was sown in drills twelve inches apart and on one farm at eighteen inches apart. In all cases, a satisfactory plant was obtained. Wheeled push hoes or tractor-mounted hoes, or both, were used with success to control weed growth. On farms where it was thought that wireworms were likely to cause damage, the seed was dressed with "Mergamma B."

Several growers felt that the usable plant population obtained in 1950 was unsatisfactory. An examination of the unusable population revealed that ninety-five per cent of the rejected plants were not acceptable because they failed to reach the minimum size required, but few, if any, were too large. One or two farmers hoped to secure a more uniform sample of plants by applying large quantities of artificial and farmyard manure. The total population of a crop treated in this way (10 cwt. compound fertilizer, plus 12 tons farmyard manure per acre) and sown at 26 lb. per acre in drills twelve inches apart, was estimated at 784,000 plants per acre on August 30. The stecklings were lifted during the latter part of October, and a yield of 400,000 usable plants per acre was obtained. This figure fell short of the grower's expectation by 80,000, but nevertheless, compared very favourably with the population of 365,000 usable plants per acre obtained from the highest yielding bed grown in 1950.

The above figures relate to crops which were grown under ideal conditions. Such yields, however, must be regarded as outstanding,

and many growers would not expect yields higher than 300,000 usable plants per acre. The profit from a yield of 300,000 usable plants per acre is not particularly attractive to the grower, and one farmer tackled this problem from another angle. He grew the stecklings as a catch crop after a ley. By top dressing the ley in early March, he was able to utilize the ley for early grazing (silage or an early hay crop could be taken) before ploughing and sowing the sugar beet seed during the first week of July. Other advantages of this method were that the weed competition was not so severe as might have been expected had the stecklings been grown after an arable crop ; also, the grower could afford to space his drills eighteen inches apart, thus making inter-row cultivations with tractor tool-bar equipment much easier.

Mild infection with Rumalaria Leaf Spot was observed on several steckling beds, but this did not have any serious effect on the crop, nor did it reduce the value of the stecklings.

All seed firms were asked to furnish the British Sugar Corporation with details of steckling beds which would require inspection for Virus Yellows. Inspectors for all the steckling beds in England and Wales were recruited from the British Sugar Corporation field personnel and N.A.A.S. officers, and trained by Dr. R. Hull at the Rothamsted Field Station, Dunholme. They worked in pairs, and a representative of the seed firm was invited to accompany them on their work.

The results of the inspections for Virus Yellows on the twenty-one steckling beds in Northumberland are given below :

*Infection** (*per cent*)	*Number of Beds*
0	13
0.01—0.10	6
0.11—0.20	—
0.21—0.30	1
0.31—0.60	—
0.61—0.70	1

The highest infection recorded was 0.63 per cent, and the average 0.055 per cent.

* The percentage of infection was based on the total plant population, and calculated from the number of plants showing symptoms in twenty 10-yard lengths of drill, which were chosen at random from each bed.

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